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Nutritional implications of dietary interventions for managing gastrointestinal disorders

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Abstract

Purpose of review: The aim of this review is to summarise some of the key dietary interventions recommended for common gastrointestinal disorders and to discuss recent evidence regarding their nutritional implications.

Recent findings: The gluten-free diet has been shown to negatively influence overall diet quality. The gluten-free diet is essential in coeliac disease, although it is increasingly used for other perceived health benefits for which an analysis of perceived benefit should be weighed against any nutritional risks. Evidence from short-term controlled trials of the low FODMAP diet in irritable bowel syndrome suggests compromised intake of nutrients such as fibre, iron and calcium, although findings vary across studies. Meanwhile long-term uncontrolled trials suggest dietary adequacy improves with reintroduction and personalisation. Although high-fibre diets may be beneficial in diverticular disease and constipation, it may lead to reductions in energy intake and nutrient absorption in at-risk populations.

Summary: The role of therapeutic diets in the management of gastrointestinal disorders is increasingly recognised, but there are limited studies investigating their nutritional implications. The judicious use of dietetic expertise should minimise potential nutritional deficits, however further prospective trials are needed to identify the individuals and nutrients most at risk.

Keywords: FODMAPs, gluten, fiber, gastrointestinal, specific carbohydrate diet

Introduction

Dietary interventions play an integral role in the management of some gastrointestinal (GI) disorders. Whilst diet remains the mainstay of treatment for coeliac disease, there has been intensifying interest in the use of diet to manage irritable bowel syndrome (IBS), constipation, diverticular disease and inflammatory bowel disease (IBD). There has been progressing momentum in the identification and/or evaluation of new dietary interventions for these disorders, but also much needed synthesis of findings in the form of systematic reviews and meta-analyses. Exclusion of one or more foods or dietary constituents for the purposes of managing GI disorders may increase the risk of inadequate nutrient intake and may have other nutritional implications. This review will summarise some of the key dietary interventions recommended for common GI disorders and discuss recent evidence regarding their nutritional implications.

Gluten-free diet

A gluten-free diet (GFD) is the only established treatment for coeliac disease and has been used since the 1950s to improve symptoms and intestinal mucosal healing (1). As the spectrum of gluten-related disorders has evolved and interest in using a GFD in irritable bowel syndrome (IBS) has emerged, there has been an increase in the numbers of people following this diet (2). This change is not confined to clinical practice, with increasing numbers of healthy people going “gluten free” for perceived health benefits (2). Although evidence consistently supports the role of a GFD in improving health in coeliac disease, dermatitis herpetiformis and gluten ataxia, the advantages of strict GFD adherence in other conditions or for lifestyle choices remains uncertain and in some cases untested (3).

Gluten describes a complex network of storage proteins found in grains such as wheat (gliadins and glutenins), rye (secalins) and barley (hordeins). It has a key role in determining rheological dough properties and baking qualities (4). Adherence to a GFD entails three components: 1) the avoidance

of foods containing gluten, 2) eating naturally occurring gluten-free foods and 3) using commercially prepared gluten-free substitute foods (3). The labelling of gluten-free foods is defined in law in Europe and North America, with food mandated to contain less than 20 ppm gluten (20 mg gluten/kg food). Although foods are not completely gluten-free, previous research has shown that this defined threshold is safe and tolerated in coeliac disease. This threshold is not universally adopted, with the Food Standards Australia New Zealand defining gluten-free as <5 ppm gluten.

Historically, concerns have been raised regarding the safety of oats in coeliac disease, leading to variations in international guidelines. This issue has recently been addressed in a systematic review and meta-analysis of 433 studies (5**). Findings support the safety of pure (uncontaminated) oats in coeliac disease, with no evidence that oats influence symptoms, histology, immunity, or serological markers.

As the use of the GFD grows and the number of available gluten-free foods rise, there has been increasing interest in the potential risks associated with a GFD. These risks relate to the inherent restrictive nature of the diet, the chemical modification of gluten-free foods as well as suboptimal dietary habits in those with coeliac disease (e.g. increased biscuit and cracker consumption (6)).

The role a GFD has on macronutrient intake is conflicting in the literature. A number of studies have shown lower carbohydrate consumption in favour of a higher fat and protein intake in people following a GFD, whilst other observational studies contradict this (2). A common finding to all studies is that the GFD is high in sugar and low in fibre. This may have implications for glycaemic control, as has been shown in a recent study demonstrating higher postprandial glycaemia for gluten-free pasta compared with conventional wheat pasta in healthy individuals (7*). Coronary heart disease risk may also be affected, with a recent cohort study examining more than 110,000

people showing risk to be highest in those with the lowest gluten consumption, with this risk attributed to a lower intake of wholegrains (8*).

In a recent review of 281 articles evaluating the nutritional quality of a GFD, in addition to fibre intake being low in individuals following a GFD, sub-optimal intakes of vitamins B12 and D, folate, iron, zinc, magnesium and calcium were also found (9*). Calcium and vitamin D are micronutrients that may warrant close monitoring in individuals following a GFD. Serum levels of both micronutrients can be low at the time of diagnosis of coeliac disease, with recent studies demonstrating serum deficiencies persisting during follow-up despite adherence to the GFD (10, 11). Heavy metal bioaccumulation may also be a consequence of a GFD, with higher urine levels of total arsenic and blood levels of mercury, lead and cadmium seen in individuals avoiding gluten (12*). These novel findings necessitate further exploration to determine what influence this has long-term health outcomes.

As understanding about GFDs evolve it is important to consider the psychosocial aspects associated with this diet. Previous research has shown that maintaining a GFD has cost implications, influences quality of life and can be socially isolating by restricting meals out (3, 13). Further work is now needed to address the long-term nutritional consequences of a GFD in individuals without coeliac disease, and determining whether gluten is really the culprit causal agent driving symptoms in these individuals.

Low FODMAP diet

Multiple randomised controlled trials (RCT) report that the low FODMAP diet leads to improvement in symptoms of irritable bowel syndrome (IBS), such as bloating and abdominal pain, in 50-80% of individuals (14*, 15), although the quality of these trials with respect to their choice of control groups and blinding has been questioned (16). The low FODMAP diet has also been investigated in

quiescent IBD, demonstrating efficacy for symptoms such as diarrhoea and bloating (17), although many trials are uncontrolled (18) and only one RCT has been published (19). The two major mechanisms by which FODMAP carbohydrates provoke GI symptoms are through increasing small intestinal water and colonic gas post-prandially (20**). Other less studied mechanisms include the effect of FODMAP carbohydrates on GI motility and the microbiome (14*).

The low FODMAP diet involves the restriction of oligosaccharides (inulin-type fructans, galacto-oligosaccharides) found in wheat and pulses, disaccharides (lactose) found in dairy products, monosaccharide (fructose in excess of glucose) found in honey, and polyols (e.g. sorbitol, mannitol) found in a variety of fruit and vegetables. Foods considered high in one or more FODMAPs are restricted for a short period of restriction period (4-6 weeks) (21). After this period, individuals should systematically reintroduce FODMAPs to determine the tolerable limits of intake. This aims to increase dietary diversity and the prebiotic content of the diet whilst maintaining symptom control (21).

The low FODMAP diet requires alteration of intake of a number of food groups including grains, fruits and vegetables, and dairy products. There is therefore a potential risk of reduced intake of certain nutrients if suitable replacements are not included. Specifically, restricted foods such as wheat products are an important source of carbohydrate, fibre, B vitamins and iron (from fortified breakfast cereals); pulses provide protein and fibre; milk provides calcium and fat-soluble vitamins; and fruit and vegetables provide a wide range of vitamins, minerals and fibre. A reduction in overall food intake could also lead to decreased energy intake.

Three recent RCTs have examined the effect of a short-term low FODMAP diet on energy intake in IBS (Table 1). In the largest RCT of the low FODMAP diet to date, energy intake was not different to those following placebo dietary advice and change in bodyweight was minimal (mean <0.5 kg) and

not different between groups (22, 26*). This contrasts with findings of two other large 4-week RCTs, where within-group reductions in energy intake were reported in the low FODMAP group (23, 27, 28). However, energy intake was also reduced in the patients in the control groups following 'standard dietary advice', suggesting this may not be unique to the low FODMAP diet, but a result of following therapeutic diets for IBS. Bodyweight was not reported in either study.

The low FODMAP diet does not lead to significant changes in protein and fat intake, however a number of studies have reported reductions in fibre intake. For example, one RCT in IBS (24) and a small uncontrolled trial in patients with radiation-induced GI symptoms (29) reported reductions in fibre intake during the low FODMAP diet compared with baseline, whereas a large randomised comparative trial reported reductions in fibre and carbohydrate intake that were more substantial than that reported in the control group receiving standard dietary advice (27). Inadequate substitution of high FODMAP grains and fruit and vegetables with suitable low FODMAP/high fibre replacements could explain these findings. However, data from another large RCT suggests no difference in fibre or macronutrient intake after a 4-week low FODMAP diet in IBS (22, 26*), and therefore it is unclear whether fibre intake is definitively at risk throughout a low FODMAP diet.

There is some data to suggest that intakes of iron, calcium and other micronutrients may be compromised during the low FODMAP diet (Table 1). One RCT in IBS has reported a within-group reduction in iron intake after low FODMAP diet compared with baseline, although no difference was found for the proportion meeting dietary iron recommendations between baseline and follow up (22, 26*). Importantly, significantly fewer achieved the recommended calcium intakes during the low FODMAP diet compared with baseline. Similarly, a substantial reduction in calcium intake has been reported for 41 patients with IBS compared with their habitual diet at baseline (23, 28). This was accompanied by a reduced intake of other micronutrients including retinol, thiamin and riboflavin. Interestingly, the only two long term studies investigating dietary intake during a modified FODMAP

diet (FODMAP personalisation, with FODMAP reintroduction to patients' tolerance), suggest calcium (24, 25*), iron and other micronutrients (25*) are not compromised at 6-18 months in patients with IBS.

Variability in the nutritional impacts of a low FODMAP diet could be due to differences in habitual diet in that population due to cultural, religious or socio-economic determinants, local availability of alternative food choices, the depth, detail and delivery method of the dietary advice provided, and whether the advice was provided by a dietitian/nutritionist.

In addition to the impact on nutrient intake, the low FODMAP diet may have psychosocial impacts. Patients have reported finding the diet 'demanding to follow' (29), and a questionnaire study reports eating out and travelling to be more difficult in those following a long-term modified FODMAP diet compared with those following their usual diet (25*). On the other hand, beneficial effects of the low FODMAP diet on health-related quality of life have been demonstrated (24, 26*), and a range of food-related quality of life scores are no different to those following a habitual diet (25*). Whether there are psychological ramifications in select patients as a result of following a long term modified FODMAP diet requires formal evaluation.

Other dietary interventions in gastrointestinal disorders

High-fibre diet

Dietary fibre manipulation is a common approach to managing some GI disorders, mostly through increasing intakes of high-fibre foods or the use of fibre supplements (e.g. psyllium). Rich sources of fibre include whole grain cereals and some fruits and vegetables and therefore a high-fibre diet is often associated with healthful properties. However, a high-fibre diet may have potentially deleterious effects on nutrient intake and status. Firstly, many trials have shown that some dietary fibres, including gel-forming and fermentable fibres, increase satiety and reduce energy intake (30).

Secondly, *in vitro* studies have shown that fibres such as cellulose and hemi-cellulose can bind calcium, iron and zinc and therefore interfere with mineral absorption, although *in vivo* studies show conflicting evidence (31). Taken together, this suggests that where a high-fibre diet is required in populations at risk of undernutrition and mineral deficiencies, these patients should be carefully monitored by a dietitian.

Despite the theoretical risk of deleterious effects, few studies investigating a high-fibre diet in GI disorders measure the consequential impact on nutrient intake. For example, a recent systematic review of 19 trials in diverticular disease described many studies where fibre led to beneficial effects in reducing or preventing symptoms of diverticulitis. The quality of studies was low, however, with few measuring compliance with the intervention or dietary intake, and many lacking randomisation or suitable control groups (32*). Furthermore, a recent meta-analysis of seven RCTs reported that fibre supplementation in constipation increased response, increased stool frequency and softened stool consistency compared with placebo (33*). However, again few of the trials reported the impact of fibre supplementation on background dietary fibre intake, let alone nutrient intake, diet quality or nutritional status.

The most recent major fibre intervention study in GI disorders was a RCT of both high-fibre diet and low-fibre diet, compared with habitual fibre, in the prevention of acute and chronic GI toxicity in 166 patients receiving pelvic radiotherapy (34*). This trial reported a smaller reduction in toxicity score in the high-fibre group both at the end of radiotherapy and 1-year following radiotherapy compared with the habitual-fibre group. Following detailed dietary counselling from a dietitian, fibre and protein intake was higher in the high-fibre diet group but with no significant impact on energy, fat and carbohydrate intake (34*).

Lactose restriction

Lactose intolerance is characterised by GI symptoms associated with lactose ingestion. The disorder is associated with the LCT-139103C>T gene variant, which has variable prevalence but is highly prevalent in Asian populations. Treatment with lactose restriction involves reduced intake of high lactose dairy foods, including milk, yoghurt and soft cheese and substitution with low lactose or lactose-free alternative plant-based products (e.g. soy, rice, nut-based), although this has variable efficacy managing GI symptoms. Concerns regarding exclusion of this entire food group centre around the adequacy of protein, calcium and vitamin D intake, although the nutritional adequacy of lactose restriction has not recently been explored. One study reported individuals with the *LCT*-13910c>T genotype consumed fewer dairy products and had lower plasma 25-(OH)D concentration (35), suggesting nutrient intake may be compromised in some who naturally restrict lactose. However, this was not a study of individuals diagnosed with lactose intolerance, therefore short- and long-term evaluation of the impact of lactose restriction in those formerly diagnosed with lactose intolerance is required to confirm the nutritional impact of this dietary intervention.

Specific-carbohydrate diet

The specific-carbohydrate diet excludes all grains (e.g. wheat, barley, corn, rice), sugars (except for honey), processed foods and milk. The diet is gaining some traction for its use in IBD, where a survey of patients showed great interest in the diet with some self-reported benefit (36). However, the specific-carbohydrate diet has not been subjected to a RCT in IBD and only data from case-series exist in the literature. For example, a retrospective review of 26 children who followed the specific-carbohydrate diet reported a reduction in disease score at four weeks and six months (37). Meanwhile the same centre reported GI symptom improvement in seven children following a modified specific-carbohydrate diet (allowing rice, oats, quinoa) but failed to show complete mucosal healing in any (38). However, a dietary analysis of eight children following the specific-carbohydrate diet reported adequate energy intakes in approximately two thirds of patients and

achievement of vitamin requirements in the majority (39*). Intakes of calcium were low but were consistent with population norms.

Conclusion

The use of diet as a therapeutic intervention in GI disorders has been driven by growing evidence of clinical efficacy and patient interest in use of diet as an alternative to drug therapy. Unfortunately, a shortcoming of diet therapy is the potential and established effects on nutrient intake and/or status. In each clinical case the likely benefit of dietary intervention should be weighed against the potential impact on nutrient intake, nutritional status and food-related quality of life. Whether individuals with GI disorders that self-modify their diet rather than seek expert guidance from a dietitian face a significantly greater risk to nutritional adequacy is unknown. In order to clarify the long-term impact of dietary interventions in GI disorders, future trials that carefully measure longitudinal dietary intake are necessary.

Key points:

- The nutritional consequences of a gluten-free diet are increasingly recognised, including reduced fibre intake and heavy metal bioaccumulation, therefore the decision to use this diet outside of coeliac disease needs to be made judiciously
- A short-term low FODMAP diet impacts on nutrient intake, specifically calcium, and in some studies fibre and iron, however prospective follow up studies are required to confirm whether this continues in the long term
- A high fibre diet may be effective in diverticular disease and constipation but careful monitoring of the impact on energy intake and micronutrient status is required

Table 1: Summary of recent trials reporting the effects of the low FODMAP diet on nutrient intake

Study	Study population	n	Duration	Dietary assessment method	Summary of findings related to nutrient intakes	
					Energy, macronutrients and fibre	Micronutrients
Randomised placebo-controlled trial (22)	IBS (Rome III)	95 (48 low FODMAP diet, 47 sham diet)	4 weeks	7-d food record	No difference in energy intake between low FODMAP diet and sham diet at follow up No difference in proportion meeting national recommendation for fibre during low FODMAP diet compared with baseline (53% vs 53% p=1.00)	Lower proportions meeting national recommendation for calcium during low FODMAP diet compared with baseline (47% vs 64%, p=0.039) Lower intakes of iron intake during low FODMAP diet compared with baseline (10 vs 11 mg/d, p=0.008)
Randomised comparative trial (23)	IBS-D (Rome III)	78 (48 low FODMAP diet, 37 mNICE diet)	4 weeks	3-d food record	Lower energy intake during low FODMAP diet compared with baseline (1691 vs 2043 kcal/d, p=0.01)	Lower intakes of retinol, thiamin, riboflavin and calcium during the low FODMAP diet compared with baseline (p<0.05)
Delayed intervention randomised controlled trial (24)	IBS (Rome III)	50 (23 low FODMAP diet, 27 delayed low FODMAP diet)	6 months Group 1: 3-month low FODMAP diet, 3-month modified FODMAP diet Group 2: 3-month wait list, 3-month low FODMAP diet	Food frequency questionnaire	Lower fibre intake after 3 months of low FODMAP diet compared with baseline for Group 1 (21 vs 33 g/d, p<0.01) and Group 2 (27 vs 31 g/d; p<0.05)	No difference in mean calcium intake during low FODMAP diet compared with baseline for either group
Uncontrolled pre- and post-study (25*)	IBS (NICE guidelines definition)	103 (84 modified low FODMAP diet, 19 habitual diet)	Between 6 and 18 months	Food frequency questionnaire	No difference in proportion meeting dietary recommendation for energy, fat, carbohydrate between modified low FODMAP diet and habitual diet Proportion meeting recommendation for protein higher in modified low FODMAP diet vs habitual diet (98% vs 79%, p=0.01)	No difference in proportion meeting dietary recommendation for fibre and 13 micronutrients between modified low FODMAP diet and habitual diet

IBS, irritable bowel syndrome; IBS-D, diarrhoea-predominant irritable bowel syndrome subtype; mNICE, modified National Institute for Health and Clinical Excellence

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